Component Values
All capacitors MLCC (Multi Layer Ceramic Capacitor).

RP08-A	Vin = 12VDC nom., C1=4.7µF/50V, C2=Not Required, C3,C4=1nF/3kV, CMC-06 Vin = 24VDC nom., C1=6.8µF/50V, C2=Not Required, C3,C4=1nF/3kV, CMC-06 Vin = 48VDC nom., C1=2.2µF/100V, C2=2.2µF/100V, C3,C4=1nF/3kV, CMC-06
RP08-AW	Vin = 9~36VDC, C1=4.7µF/50V, C2=Not Required, C3,C4=1nF/3kV, CMC-06 Vin = 18~75VDC, C1=2.2µF/100V, C2=2.2µF/100V, C3,C4=1nF/3kV, CMC-06
RP10-E RP12-A	Vin = 12VDC nom., C1=3.3µF/50V, C2=Not Required, C3,C4=1nF/2kV, CMC-06 Vin = 24VDC nom., C1=4.7µF/50V, C2=Not Required, C3,C4=1nF/2kV, CMC-06 Vin = 48VDC nom., C1=2.2µF/100V, C2=2.2µF/100V, C3,C4=1nF/2kV, CMC-06
RP10-EW RP12-AW	Vin = 9~36VDC, C1=3.3µF/50V, C2=Not Required, C3,C4=1nF/2kV, CMC-06 Vin = 18~75VDC, C1=2.2µF/100V, C2=2.2µF/100V, C3,C4=1nF/2kV, CMC-07
RP15-A	Vin = 12VDC nom., C1=10µF/25V, C2=10µF/25V, C3,C4=470pF/2kV, CMC-07 Vin = 24VDC nom., C1=6.8µF/50V, C2=6.8µF/50V, C3,C4=470pF/2kV, CMC-06 Vin = 48VDC nom., C1=2.2µF/100V, C2=2.2µF/100V, C3,C4=470pF/2kV, CMC-01
RP15-AW	Vin = 9~36VDC, C1=6.8µF/50V, C2=6.8µF/50V, C3,C4=470pF/2kV, CMC-05 Vin = 18~75VDC, C1=2.2µF/100V, C2=2.2µF/100V, C3,C4=470pF/2kV, CMC-06
RP15-O	Vin = 12VDC nom., C1=10µF/25V, C2=10µF/25V, L1 = 10µH, , CMC-07 Vin = 24VDC nom., C1=6.8µF/50V, C2=6.8µF/50V, L1 = 10µH, , CMC-07 Vin = 48VDC nom., C1=2.2µF/100V, C2=2.2µF/100V, L1 = 18µH, CMC-07
RP15-OW	Vin = 9~36VDC, C1, C2, C3 =6.8µF/50V, CMC-07 Vin = 18~75VDC, C1=2 x 2.2µF/100V in parallel, C2,C3 =2.2µF/100V, L1 = 33µH, CMC-06
RP15-F	Vin = 12VDC nom., C1=4.7µF/50V, C2=Not Required, C3,C4=1nF/2kV, CMC-06 Vin = 24VDC nom., C1=3.3µF/50V, C2=Not Required, C3,C4=1nF/2kV, CMC-06 Vin = 48VDC nom., C1=2.2µF/100V, C2=2.2µF/100V, C3,C4=1nF/2kV, CMC-06
RP15-FW	Vin = 9~36VDC, C1=2.2µF/50V, C2=Not Required, C3,C4=1nF/2kV, CMC-05 Vin = 18~75VDC, C1=2.2µF/100V, C2=2.2µF/100V, C3,C4=1nF/2kV, CMC-06
RP20-F	Vin = 12VDC nom., C1=4.7µF/50V, C2=Not Required, C3,C4=1nF/2kV, CMC-05 Vin = 24VDC nom., C1=4.7µF/50V, C2=Not Required, C3,C4=1nF/2kV, CMC-05 Vin = 48VDC nom., C1=2.2µF/100V, C2=2.2µF/100V, C3,C4=1nF/2kV, CMC-05
RP20-FW	Vin = 9~36VDC, C1=4.7µF/50V, C2=Not Required, C3,C4=1nF/2kV, CMC-05 Vin = 18~75VDC, C1=2.2µF/100V, C2=2.2µF/100V, C3,C4=1nF/2kV, CMC-06
RP30-E	Vin = 12VDC nom., C1=4.7µF/25V, C2=Not Required, C3,C4=1nF/2kV, CMC-05 Vin = 24VDC nom., C1=6.8µF/50V, C2=6.8µF/50V, C3,C4=1nF/2kV, CMC-05 Vin = 48VDC nom., C1=2.2µFII2.2µF/100V, C2=2.2µFII2.2µF/100V, C3,C4=1nF/2kV, CMC-05
RP30-EW	Vin = 9~36VDC, C1=6.8µF/50V, C2=6.8µF/50V, C3,C4=1nF/2kV, CMC-05 Vin = 18~75VDC, C1=2.2µF II 2.2µF/100V, C2=2.2µF II 2.2µF/100V, C3,C4=1nF/2kV, CMC-05

Continued on next page

RP30-F
Vin = 12VDC nom., C1, C2, C3 =10µF/25V, C4, C5, C6=1nF/2kV, CMC1 = CMC-09, CMC2 = CMC-10
Vin = 24VDC nom., C1, C2, C3 =4.7µF/50V, C4, C5, C6=1nF/2kV, CMC1 = CMC-09, CMC2 = CMC-10
Vin = 48VDC nom., C1, C2, C3 =2.2µF/100V, C4, C5, C6=1nF/2kV, CMC1 = CMC-09, CMC2 = CMC-10

RP30-FW
Vin = 9~36VDC, C1, C2, C3 =4.7µF/50V, C4, C5, C6=1nF/2kV, CMC1 = CMC-09, CMC2 = CMC-10
Vin = 18~75VDC, C1, C2, C3 =4.7µF/50V, C4, C5, C6=1nF/2kV, CMC1 = CMC-09, CMC2 = CMC-10

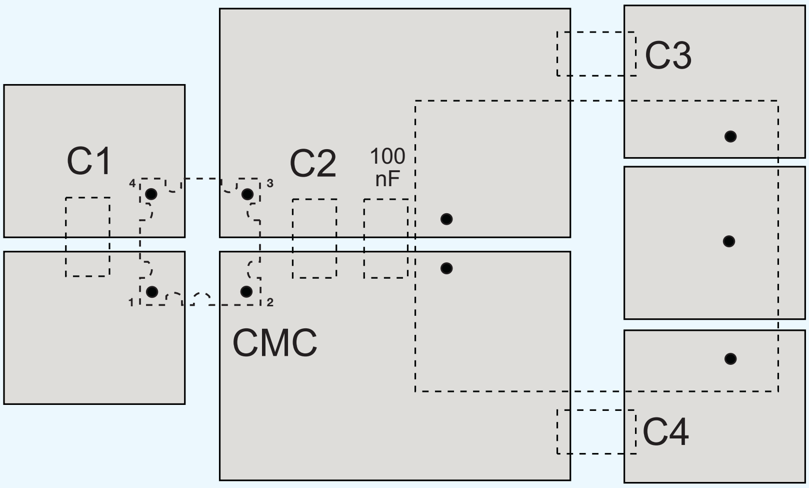
RP40-G
Vin = 12VDC nom., C1=4.7µF/50V, C2=Not Required, C3,C4=1nF/2kV, CMC-05
Vin = 24VDC nom., C1=6.8µF/50V, C2=6.8µF/50V, C3,C4=1nF/2kV, CMC-05
Vin = 48VDC nom., C1=2.2µF II 2.2µF/100V, C2=2.2µF II 2.2µF/100V, C3,C4=1nF/2kV, CMC-08

RP40-GW
Vin = 9~36VDC, C1=4.7µF/50V, C2=4.7µF/50V, C3,C4=1nF/2kV, CMC-05
Vin = 18~75VDC, C1=2.2µF II 2.2µF/100V, C2=2.2µF II 2.2µF/100V, C3,C4=1nF/2kV, CMC-08

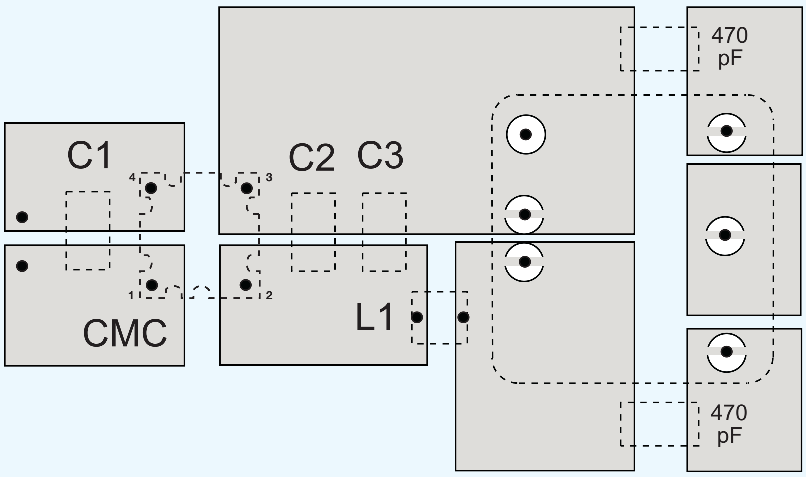
RP60-G
Vin = 24VDC nom., C1=4.7µF/50V, C2=4.7µF/50V, C3,C4=1nF/2kV, CMC-05
Vin = 48VDC nom., C1=2.2µF II 2.2µF/100V, C2=2.2µF II 2.2µF/100V, C3,C4=1nF/2kV,CMC-08

Recommended PCB Layouts

Standard EMC Filter

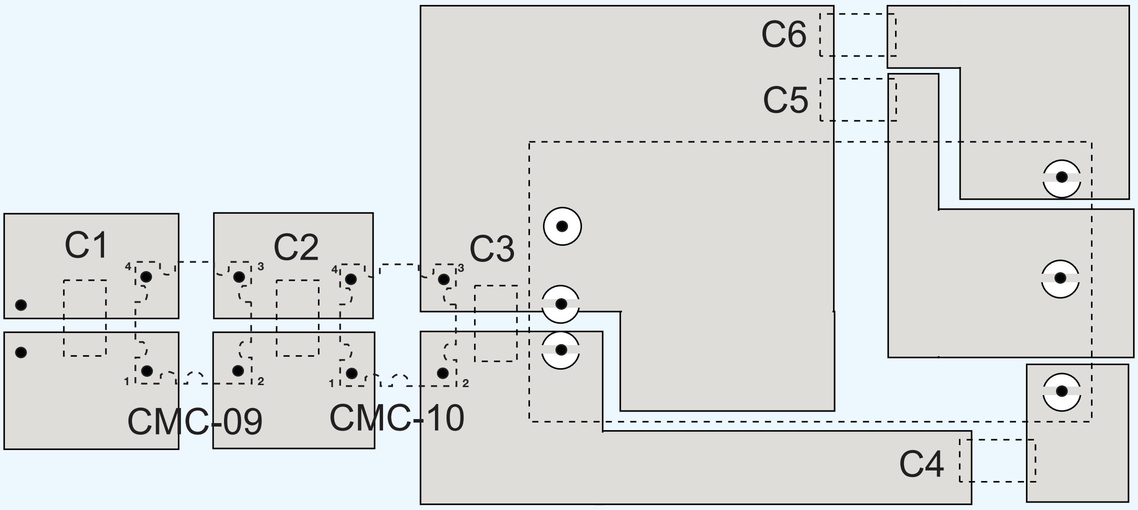


RP15-0 Open Frame Converters



Recommended PCB Layouts

RP30-S_DF
RP30-S_DFW

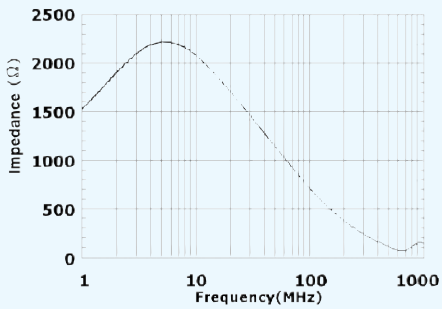


General Information about Recom Common Mode Chokes

Recom common mode chokes are all RoHS conform.

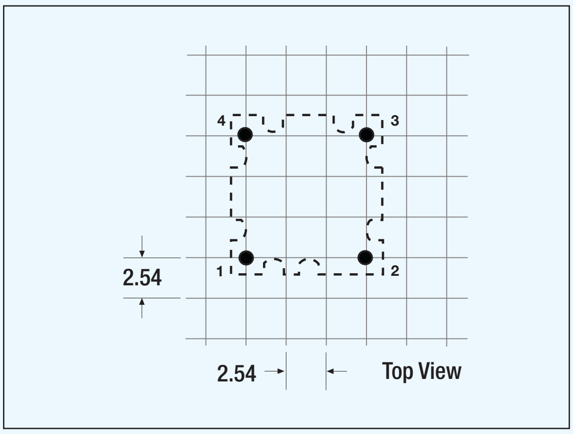
Maximum Rated Voltage = 500VDC

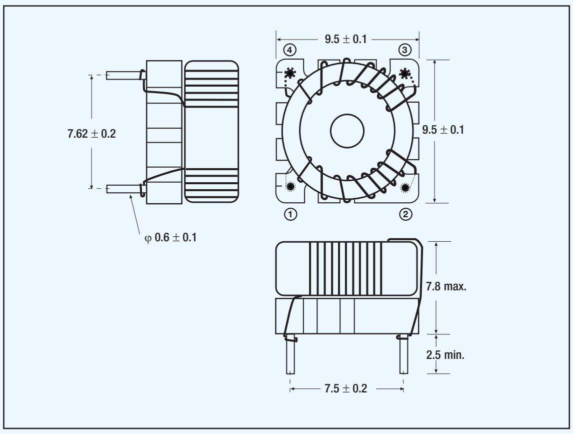
Operating Temperature = -40°C ~ +105°C



Typical Impedance curve (CMC-08)

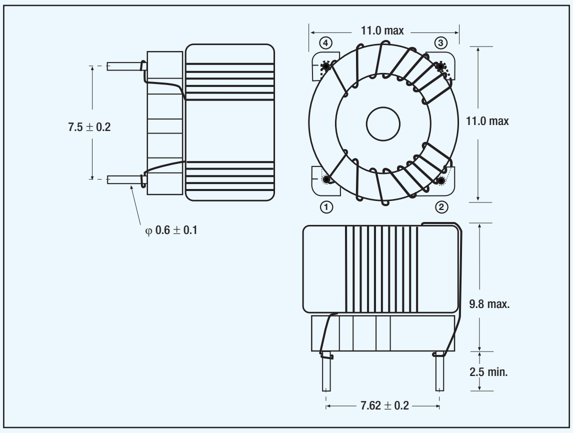
Recommended Footprint Details





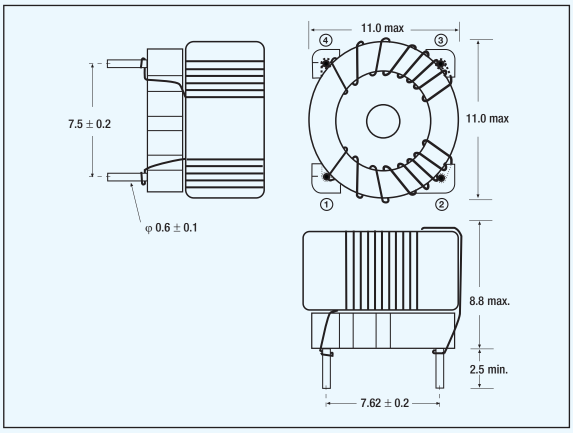
CMC-01

Component	Inductance	Rating	DCR
CMC-01	620µHx2	1.7A	80mOhm



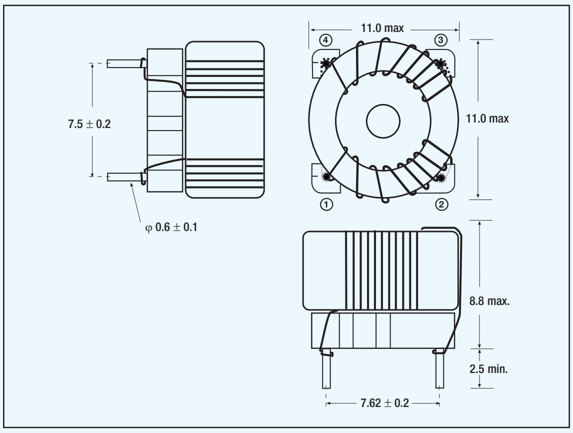
CMC-05

Component	Inductance	Rating	DCR
CMC-05	450µHx2	5.2A	25mOhm



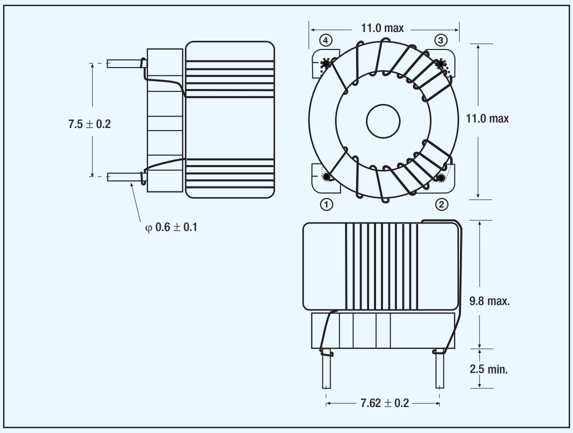
CMC-06

Component	Inductance	Rating	DCR
CMC-06	325µHx2	3.3A	35mOhm



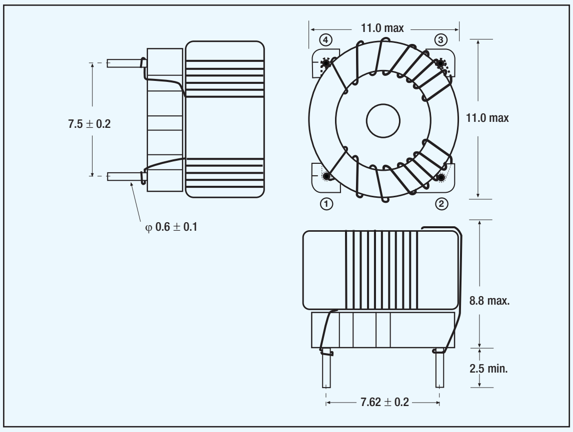
CMC-07

Component	Inductance	Rating	DCR
CMC-7	145µHx2	5.2A	20mOhm



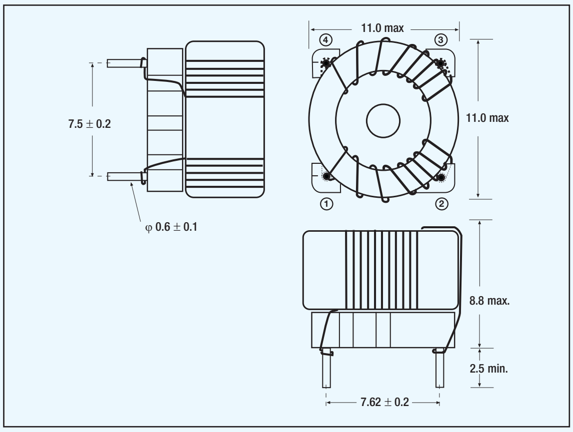
CMC-08

Component	Inductance	Rating	DCR
CMC-8	830µHx2	5.2A	31mOhm



CMC-09

Component	Inductance	Rating	DCR
CMC-7	33,3µHx2	3.3A	10mOhm



CMC-10

Component	Inductance	Rating	DCR
CMC-10	55µHx2	4A	7mOhm

Definitions and Testing

General Test Set-Up

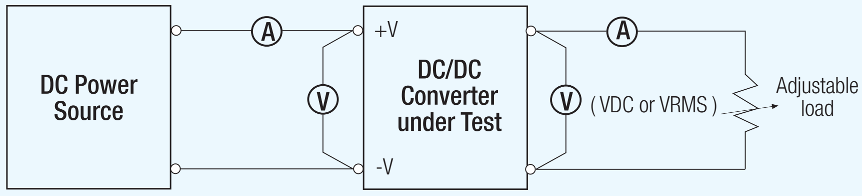


Figure 1-3: General DC/DC converter test set-up

Note: If the converter is under test with remote sense pins, connect these pins to their respective output pins. All tests are made in "Local sensing" mode.

Input Voltage Range

The minimum and maximum input voltage limits within which a converter will operate to specifications.

PI Filter

An input filter, consisting of two capacitors, connected before and after a series inductor to reduce input reflected ripple current. The effective filter is C1/L + L/C2, so the inductor filter element is doubly effective.

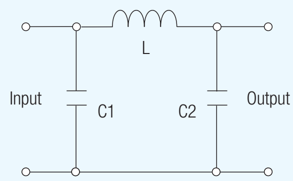


Figure 2: PI Filter

Output Voltage Accuracy

With nominal input voltage and rated output load from the test set-up, the DC output voltage is measured with an accurate, calibrated DC voltmeter. Output voltage accuracy is the difference between the measured output voltage and specified nominal value as a percentage. Output accuracy (as a %) is then derived by the formula:

$$\frac{V_{out} - V_{nom}}{V_{nom}\ N} \times 100$$

V_{nom} is the nominal output specified in the converter data sheet.

Voltage Balance

For a multiple output power converter, the percentage difference in the voltage level of two outputs with opposite polarities and equal nominal values.

Line Regulations

Make and record the following measurements with rated output load at +25°C:

- Output voltage at nominal line (input) voltage. V_{out} N
- Output voltage at high line (input) voltage. V_{out} H
- Output voltage at low line (input) voltage. V_{out} L

The line regulation is Vout M (the maximum of the two deviations of output) for the value at nominal input in percentage.

$$\frac{V_{out}\ M - V_{out}\ N}{V_{out}\ N} \times 100$$

Definitions and Testing

Load Regulation

Make and record the following measurements with rated output load at +25°C:

- Output voltage with rated load connected to the output. (Vout FL)
- Output voltage with no load or the minimum specified load for the DC-DC converter. (Vout ML)

Load regulation is the difference between the two measured output voltages as a percentage of output voltage at rated load.

$$\frac{V_{out}\,ML - V_{out}\,FL}{V_{out}\,FL} \; X100$$

Efficiency

The ratio of output load power consumption to input power consumption expressed as a percentage. Normally measured at full rated output power and nominal line conditions.

Switching Frequency

The rate at which the DC voltage is switched in a DC-DC converter or switching power supply. The ripple frequency is double the switching frequency in push-pull designs.

Output Ripple and Noise

Because of the high frequency content of the ripple, special measurement techniques must be employed so that correct measurements are obtained. A 20MHz bandwidth oscilloscope is used, so that all significant harmonics of the ripple spike are included.
This noise pickup is eliminated as shown in Figure 3, by using a scope probe with an external connection ground or ring and pressing this directly against the output common terminal of the power converter, while the tip contacts the voltage output terminal. This provides the shortest possible connection across the output terminals.

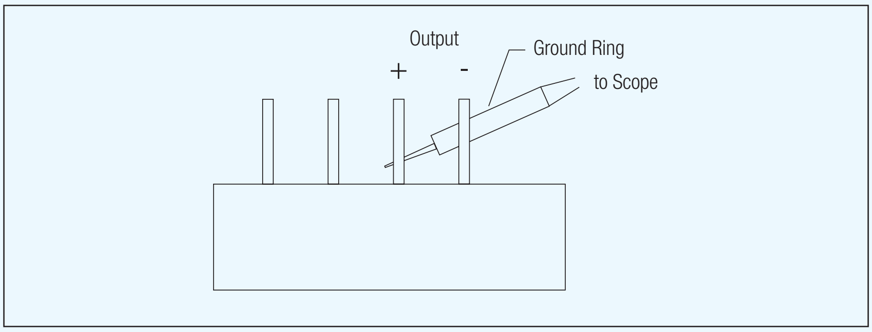


Figure 3:

Definitions and Testing

Output Ripple and Noise (continued)

Figure 4 shows a complex ripple voltage waveform that may be present on the output of a switching power supply. There are three components in the waveform, first is a charging component that originates from the output rectifier and filter, then there is the discharging component due to the load discharging the output capacitor between cycles, and finally there are small high frequency switching spikes imposed on the low frequency ripple.

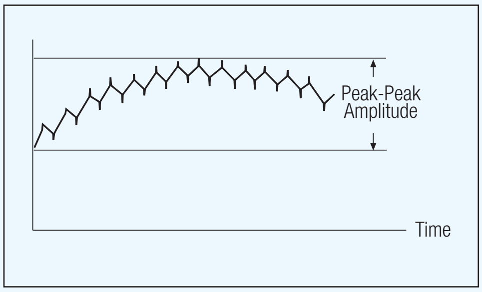


Figure 4: Amplitude

Transient Recovery Time

The time required for the power supply output voltage to return to within a specified percentage of rated value, following a step change in load current.

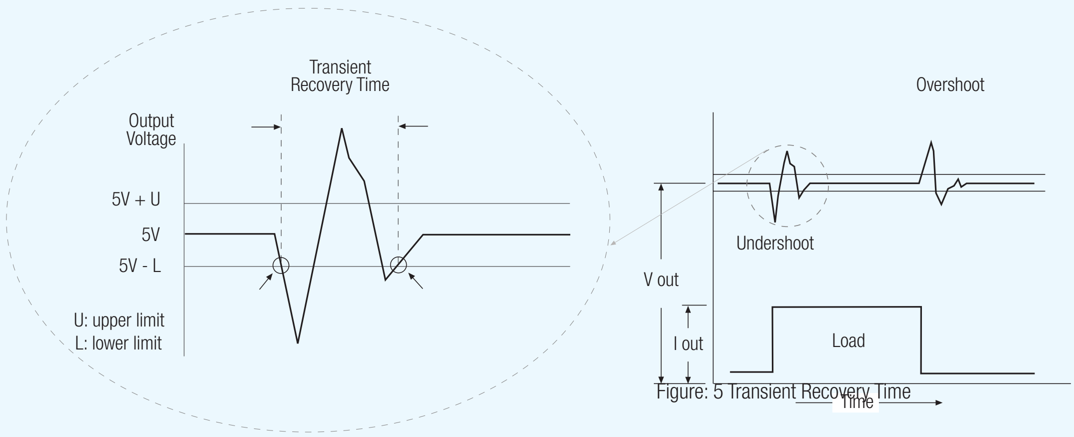


Figure: 5 Transient Recovery Time

Current Limiting

output current is limited to prevent damage of the converter at overload situations. If the output is shorted, the output voltage is regulated down so the current from the outputs cannot be excessive.

Fold Back Current Limiting

A method of protecting a power supply from damage in an overload condition, reducing the output current as the load approaches short circuit.

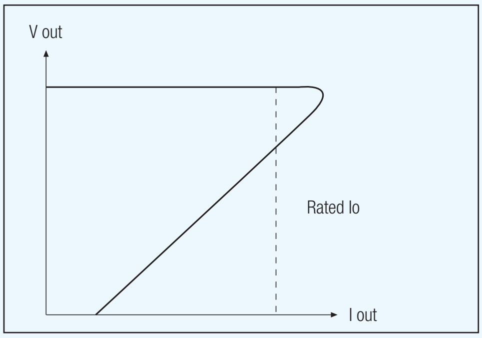


Figure 6: Fold Back Current LimitingTime

Definitions and Testing

Isolation

The electrical separation between the input and output of a converter, (consisting of resistive and capacitive isolation) normally determined by transformer-characteristics and circuit spacing.

Break-Down Voltage

The maximum continuous DC voltage, which may be applied between the input and output terminal of a power supply without causing damage.
Typical break-down voltage for DC-DC converters is 1600VDC because the equivalent DC isolation for 230VAC continuous rated working voltage is 1500VDC.

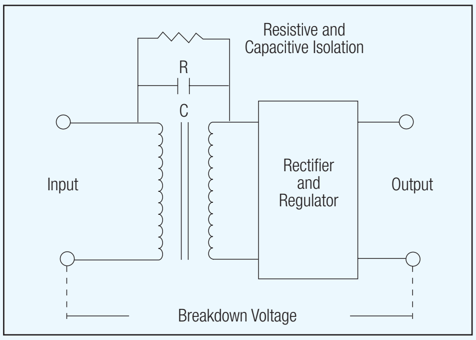


Figure 7:

Temperature Coefficient

With the power converter in a temperature test chamber at full rated output load, make the following measurements:

- Output voltage at +25°C ambient temperature.
- Set the chamber for maximum operating ambient temperature and allow the power converter to stabilize for 15 to 30 minutes. Measure the output voltage.
- Set the chamber to minimum operating ambient temperature and allow the power converter to stabilize for 15 to 30 minutes.
- Divide each percentage voltage deviation from the +25°C ambient value by the corresponding temperature change from +25°C ambient.

The temperature coefficient is the higher one of the two values calculated above, expressed as percent per change centigrade.

Ambient Temperature

The temperature of the still-air immediately surrouding an operating power supply. Care should be taken when comparing manufacturer's datasheets that still-air ambient temperature and not case temperature is quoted.

Operating Temperature Range

The range of ambient or case temperature within a power supply at which it operates safely and meets its specifications.

Storage Temperature Range

The range of ambient temperatures within a power supply at non-operating condition, with no degradation in its subsequent operation.

Trim Tables

Output Voltage Trimming:

Some converters from our Powerline offer the feature of trimming the output voltage in a certain range around the nominal value by using external trim resistors.
Because different series use different circuits for trimming, no general equation can be given for calculating the trim resistors.

The following trimtables give values for chosing these trimming resistors.
If voltages between the given trim points are required, extrapolate between the two nearest given values to work out the resistor required or use a variable resistor to set the voltage.

Single Output Voltage Trim Tables

RP15-, RP20-, RP30-, RP40-, RP60- xx3.3S (For RP15-SA/SAW and RP15-SO/SOW see next page)

Trim up	1	2	3	4	5	6	7	8	9	10	%
Vout =	3,333	3,366	3,399	3,432	3,465	3,498	3,531	3,564	3,597	3,63	Volts
R_U =	57.93	26.16	15.58	10.28	7.11	4.99	3.48	2.34	1.46	0.75	KOhms
Trim down	1	2	3	4	5	6	7	8	9	10	%
Vout =	3,267	3,234	3,201	3,168	3,135	3,102	3,069	3,036	3,003	2,97	Volts
R_D =	69.47	31.23	18.49	12.12	8.29	5.74	3.92	2.56	1.50	0.65	KOhms

RP15-, RP20-, RP30-, RP40-, RP60- xx05S (For RP15-SA/SAW and RP15-SO/SOW see next page)

Trim up	1	2	3	4	5	6	7	8	9	10	%
Vout =	5,05	5,1	5,15	5,2	5,25	5,3	5,35	5,4	5,45	5,5	Volts
R_U =	36.57	16.58	9.92	6.58	4.59	3.25	2.30	1.59	1.03	0.59	KOhms
Trim down	1	2	3	4	5	6	7	8	9	10	%
Vout =	4,95	4,9	4,85	4,8	4,75	4,7	4,65	4,6	4,55	4,5	Volts
R_D =	45.53	20.61	12.31	8.15	5.66	4.00	2.81	1.92	1.23	0.68	KOhms

RP15-, RP20-, RP30-, RP40- ,RP60-xx12S (For RP15-SA/SAW and RP15-SO/SOW see next page)

Trim up	1	2	3	4	5	6	7	8	9	10	%
Vout =	12,12	12,24	12,36	12,48	12,6	12,72	12,84	12,96	13,08	13,2	Volts
R_U =	367.91	165.95	98.64	64.98	44.78	31.32	21.70	14.49	8.88	4.39	KOhms
Trim down	1	2	3	4	5	6	7	8	9	10	%
Vout =	11,88	11,76	11,64	11,52	11,4	11,28	11,16	11,04	10,92	10,8	Volts
R_D =	460.99	207.95	123.60	81.42	56.12	39.25	27.20	18.16	11.13	5.51	KOhms

RP15-, RP20-, RP30-, RP40-, RP60- xx15S (For RP15-SA/SAW and RP15-SO/SOW see next page)

Trim up	1	2	3	4	5	6	7	8	9	10	%
Vout =	15,15	15,3	15,45	15,6	15,75	15,9	16,05	16,2	16,35	16,5	Volts
R_U =	404.18	180.59	106.06	68.80	46.44	31.53	20.88	12.90	6.69	1.72	KOhms
Trim down	1	2	3	4	5	6	7	8	9	10	%
Vout =	14,85	14,7	14,55	14,4	14,25	14,1	13,95	13,8	13,65	13,5	Volts
R_D =	499.82	223.41	131.27	85.20	57.56	39.14	25.97	16.10	8.42	2.282	KOhms

Trim Tables

RP15-S_DA, RP15 S:DAW Output Voltage Trim Tables

RP15-xx3.3SA, RP15-xx3.3SAW, RP15-xx3.3SO, RP15-xx3.3SOW

Trim up	1	2	3	4	5	6	7	8	9	10	%
Vout =	3,333	3,366	3,399	3,432	3,465	3,498	3,531	3,564	3,597	3,63	Volts
R_U =	385.07	191.51	126.99	94.73	75.37	62.47	53.25	46.34	40.96	36.66	KOhms
Trim down	1	2	3	4	5	6	7	8	9	10	%
Vout =	3,267	3,234	3,201	3,168	3,135	3,102	3,069	3,036	3,003	2,97	Volts
R_D =	116.72	54.78	34.13	23.81	17.62	13.49	10.54	8.32	6.60	5.23	KOhms

RP15-xx05SA, RP15-xx05SAW, RP15-xx05SO, RP15-xx05SOW

Trim up	1	2	3	4	5	6	7	8	9	10	%
Vout =	5,05	5,1	5,15	5,2	5,25	5,3	5,35	5,4	5,45	5,5	Volts
R_U =	253.45	125.70	83.12	61.82	49.05	40.53	34.45	29.89	26.34	23.50	KOhms
Trim down	1	2	3	4	5	6	7	8	9	10	%
Vout =	4,95	4,9	4,85	4,8	4,75	4,7	4,65	4,6	4,55	4,5	Volts
R_D =	248.34	120.59	78.01	56.71	43.94	35.42	29.34	24.78	21.23	18.39	KOhms

RP15-xx12SA, RP15-xx12SAW, RP15-xx12SO, RP15-xx12SOW

Trim up	1	2	3	4	5	6	7	8	9	10	%
Vout =	12,12	12,24	12,36	12,48	12,6	12,72	12,84	12,96	13,08	13,2	Volts
R_U =	203.22	99.06	64.33	46.97	36.56	29.61	24.65	20.93	18.04	15.72	KOhms
Trim down	1	2	3	4	5	6	7	8	9	10	%
Vout =	11,88	11,76	11,64	11,52	11,4	11,28	11,16	11,04	10,92	10,8	Volts
R_D =	776.56	380.72	248.78	182.81	143.22	116.83	97.98	83.85	72.85	64.06	KOhms

RP15-xx15SA, RP15-xx15SAW, RP15-xx15SO, RP15-xx15SOW

Trim up	1	2	3	4	5	6	7	8	9	10	%
Vout =	15,15	15,3	15,45	15,6	15,75	15,9	16,05	16,2	16,35	16,5	Volts
R_U =	161.56	78.22	50.45	36.56	28.22	22.67	18.70	15.72	13.41	11.56	KOhms
Trim down	1	2	3	4	5	6	7	8	9	10	%
Vout =	14,85	14,7	14,55	14,4	14,25	14,1	13,95	13,8	13,65	13,5	Volts
R_D =	818.22	401.56	262.67	193.22	151.56	123.78	103.94	89.06	77.48	68.22	KOhms

Trim Tables

Dual Output Voltage Trim Tables

RP15-, RP20- xx05D

Trim up	1	2	3	4	5	6	7	8	9	10	%
Vout =	10,1	10,2	10,3	10,4	10,5	10,6	10,7	10,8	10,9	11	Volts
R_U =	90.30	40.60	24.03	15.75	10.78	7.47	5.1	3.32	1.94	0.84	KOhms
Trim down	1	2	3	4	5	6	7	8	9	10	%
Vout =	9,9	9,8	9,7	9,6	9,5	9,4	9,3	9,2	9,1	9	Volts
R_D =	109.3	49.00	28.90	18.85	12.82	8.80	5.93	3.77	2.10	0.76	KOhms

RP15-, RP20, RP30- xx12D

Trim up	1	2	3	4	5	6	7	8	9	10	%
Vout =	24,24	24,48	24,72	24,96	25,2	25,44	25,68	25,92	26,16	26,4	Volts
R_U =	218.21	98.10	58.07	38.05	26.04	18.03	12.32	8.03	4.69	2.02	KOhms
Trim down	1	2	3	4	5	6	7	8	9	10	%
Vout =	23,76	23,52	23,28	23,04	22,8	22,56	22,32	22,08	21,84	21,6	Volts
R_D =	273.44	123.02	72.87	47.80	32.76	22.73	15.57	10.20	6.02	2.67	KOhms

RP15-, RP20-, RP30-- xx15D

Trim up	1	2	3	4	5	6	7	8	9	10	%
Vout =	30,3	30,6	30,9	31,2	31,5	31,8	32,1	32,4	32,7	33	Volts
R_U =	268.29	120.64	71.43	46.82	32.06	22.21	15.1	9.91	5.81	2.53	KOhms
Trim down	1	2	3	4	5	6	7	8	9	10	%
Vout =	29,7	29,4	29,1	28,8	28,5	28,2	27,9	27,6	27,3	27	Volts
R_D =	337.71	152.02	90.13	59.18	40.61	28.23	19.39	12.76	7.60	3.47	KOhms

RECOM

Undervoltage Lockout

Undervoltage Lockout

At low input voltages, the input currents can exceed the rating of the converter. Therefore, converters featuring under-voltage lockout will automitically shut down if the input voltage is too low. As the input voltage rises, they will restart.

Undervoltage Lockout Tables

Converter Series	Nominal Input Voltage	Switch ON input voltage	Switch OFF input voltage
RP08-S_DAW	24V (9~36VDC) 48V (18~75VDC)	9VDC 18VDC	8VDC 16VDC
RP12-S_DA	12V (9~18VDC) 24V (18~36VDC) 48V (36~75VDC)	9VDC 18VDC 36VDC	8VDC 16VDC 33VDC
RP12-S_DAW	24V (9~36VDC) 48V (18~75VDC)	9VDC 18VDC	8VDC 16VDC
RP15-S_DA, RP15-S_DO	12V (9~18VDC) 24V (18~36VDC) 48V (36~75VDC)	9VDC 17VDC 33VDC	8VDC 14.5VDC 30.5VDC
RP15-S_DAW, RP15-S_DOW	24V (9~36VDC) 48V (18~75VDC)	9VDC 18VDC	8VDC 16VDC
RP15-S_DFW	24V (9~36VDC) 48V (18~75VDC)	9VDC 18VDC	7.5VDC 15VDC
RP20-S_DFW	24V (9~36VDC) 48V (18~75VDC)	9VDC 18VDC	7.5VDC 15VDC
RP30-S_DE	12V (9~18VDC) 24V (18~36VDC) 48V (36~75VDC)	9VDC 17.8VDC 36VDC	8VDC 16VDC 33VDC
RP30-S_DEW	24V (10~40VDC) 48V (18~75VDC)	10VDC 18VDC	8VDC 16VDC
RP40-S_D_TG	12V (9~18VDC) 24V (18~36VDC) 48V (36~75VDC)	9VDC 17.8VDC 36VDC	8VDC 16VDC 34VDC
RP30-S_DGW	24V (9~36VDC) 48V (18~75VDC)	9VDC 18VDC	8VDC 16VDC
RP60-SG	24V (18~36VDC) 48V (36~75VDC)	17VDC 34VDC	15VDC 32VDC

Thermal Management- The Laws of Thermodynamics

Smaller, more powerful, better performance …are the buzzwords in the area of DC/DC module power supplies. Good thermal management of the heat generated has become an important part of the design-process. But what needs to be done?

An indisputable fact is that the efficiency of any energy conversion process is always less than 100%. This means that a part of the energy being converted goes astray as heat and that ultimately this waste heat must be removed. The laws of thermodynamics state that heat energy can only flow from a warmer to a colder environment. So, for DC/DC converters, this means that if the internal heat is to be dissipated out of the module, that the ambient temperature must always be lower than the maximum allowable internal temperature. The larger this difference, the more effectively waste heat can flow out of the converter.

But which temperature specifications in the datasheets are to be consulted for the thermal calculations? RECOM declares two values in its datasheets, Operating Temperature Range (with or without derating) and the Maximum Case Temperature. Some manufacturers even claim that these two values are the same.

The case (surface) temperature of DC/DC modules are typically given as around +100°C. This value appears at first to be very high; however this figure includes not only the self-warming through internal losses but also the ambient temperature itself.

Remember: The smaller the difference between case surface and ambient, so the smaller the amount of heat that can be lost to the surroundings. If a converter has high internal dissipation, then it will be more affected by a small temperature difference than a converter with low internal dissipation. The internal losses occur mainly through switching losses in the transistors, rectification losses, core losses in the transformer and resistive losses in the windings and tracks. The maximum allowable internal temperature is determined by either the curie temperature of the transformer core material, the maximum junction temperature of the switching transistors or rectification diodes or the maximum operating temperature of the capacitors: whichever is the lowest.

Thermal Management- Thermal Impedance

The Thermal Impedance is a measure of how effectively heat can flow from inside the converter to its surroundings. It is measured in °C/Watt. It is possible to further lower the thermal resistance to ambient by fitting an external heat sink as this increases the surface area from which heat can be transferred to the surrounding air. The thermal impedance can also be lowered by blowing air across the converter as moving air can transfer more heat away from the converter as stationary air.

Recom datasheets always show the thermal impedance without a heatsink and with natural convection (still air).

The datasheets also state the minimum and maximum ambient operating temperature rather than just the maximum case temperature because this is easiest for the end user to measure and to monitor. The advantage is that true ambient temperature can be measured in the actual application and it need not be calculated theoretically, plus the results are valid for both sealed and vented constructions with a through-flow of cooling air.

Nevertheless, the maximum case temperature is useful to decide on a suitably dimensioned heat sink so that the maximum case temperature is not exceeded at the maximum ambient temperature.

The internal losses and thermal resistances can also be derived mathematically.
For the calculations, Ohm's Law of R=V/I can be modified so that R becomes thermal resistance, V becomes temperature and I becomes power dissipation. The following equations can thus be derived:

$$R_{THcase-ambient} = \frac{T_{case} - T_{ambient}}{P_{dissipation}}$$

$$P_{dissipation} = P_{in} - P_{out} = \frac{P_{out}}{\eta(oper)} - P_{out}$$

where
R THcase-ambient = Thermal impedance (from the case to the ambient surroundings)
T case =Case temperature
T ambient=Environment temperature
P dissipation =Internal losses
P in =Input power
P out =Output power
η(oper) =efficiency under the given operating conditions

With help of the above formulae, the maximum allowable ambient temperature for a given set of operating conditions can be calculated - but it is important to remember that efficiency is dependent on both the output load and the input voltage.

The formulae also demonstrate that case temperature is not the same as operating temperature, as is so often falsely claimed.

A practical example:
Take the RP30-4805SE with 80% load:
What is the maximum operating temp?

From the datasheet text and graphs, the following information can be found:
R THcase-ambient = 10°C/W
T case = 100°C maximum
T ambient=unknown

P dissipation must be calculated from:
P out = 30 x 80% = 24W
η(oper) = 90% (from Eff vs Load Graph)
P diss. = 24/0.9 -24 = 2.66 Watts.

Thus
10W/°C = (100 - T amb) / 2.66W
and T amb max. = 73.4°C

At 100% load, this figure reduces to 64.4°C

At 100% load and over the full input voltage range, this figure reduces further to 59.1°C

If the thermal dissipation calculations reveal that the DC/DC Module will overheat at the desired ambient operating temperature, then there are still a number of options available to reach a solution.

One option is to derate the converter, i.e, use a higher power converter running at less than full load. The derating diagrams in the datasheets essentially define the maximum load at any given temperature within the operating temperature range. The derating curves are in reality not so linear as they are declared in most datasheets. However, reliable manufacturers will always err on the safe side so that the values given can be safely relied on in practice.

If the converter has a plastic case, then the next largest case size with the same power rating could be chosen to increase the available surface area. However, care must be taken not to compromise on efficiency otherwise no net gain will be made.

Thermal Management-
Heat Sinking

If the converter has a metal case, then adding a heat sink is can be very effective, particularly in conjunction with a forced-air cooling system. If a heat sink is used with fan cooling, then the thermal resistance equation becomes:

$R_{THcase\text{-}ambient} = R_{THcase\text{-}heatsink} + R_{THheatsink\text{-}ambient}$

where
$R_{THcase\text{-}ambient}$ =Thermal impedance
(from the case to the ambient surroundings)

$R_{THcase\text{-}heatsink}$ =Thermal impedance
(from the case to the heat sink)

$R_{THheatsink\text{-}ambient}$ =Thermal impedance
(from the heat sink to ambient)

The value of RTH heatsink-ambient includes the thermal resistance of the heat sink as well as the thermal resistance of any thermally conductive paste or silicon pads used for a better thermal contact to the case. If these heat transfer aids are not applied, then a value of approximately 0.2 K/W must be added to the thermal resistance of the heat sink alone. When establishing of the value of RTH heatsink-ambient it is also necessary to know how much air is being blown across the heat sink fins. These values are most often given in lfm (linear feet per minute) and declared by the fan manufacturer. The conversion to m/s is 100lfm = 0.5 m/s.

Calculation of heatsinks size:

Example: RP30-2405SEW starts derating without heatsink at +65°C but the desired operation is 30W at +75°C so the size of the heatsink has to be calculated.

$P_{out} = 30W$
Efficiency = 88% max.

$P_d = \frac{P_{out}}{Efficiency} - P_{out} = \frac{30W}{88\%} - 30W = 4.1W$

$T_{case} = 100°C$ (max. allowed case temperature)
$T_{ambient} = 75°C$

$R_{THcase\text{-}ambient} = \frac{T_{case} - T_{ambient}}{P_D} = \frac{100°C-75°C}{4.1°C}$
$= 6.1°C/W$

So it has to be ensured that the thermal resistance between case and ambient is 6,1°C/W max.

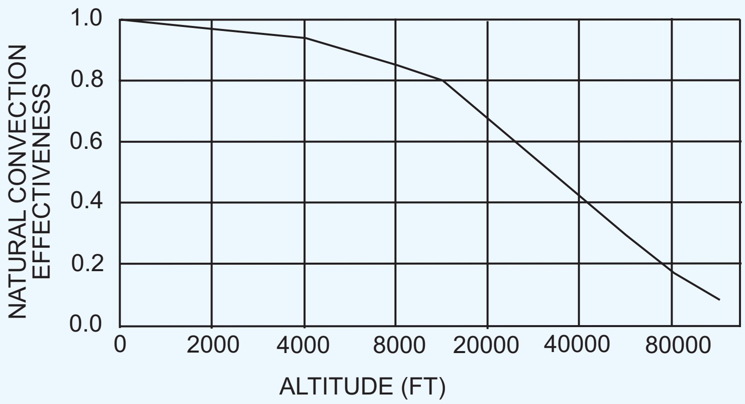
When mounting a heatsink on a case there is a thermal resistance $R_{TH\ case\text{-}heatsink}$ between case and heatsink which can be reduced by using thermal conductivity paste but cannot be eliminated totally.

Heatsink mounted on case without thermal conductivity paste	$R_{TH\ case\text{-}heatsink}$ = ca. 1…2 °C/W
Heatsink mounted on case with thermal conductivity paste	$R_{TH\ case\text{-}heatsink}$ = ca. 0,5…1 °C/W
Heatsink mounted on case with thermal conductivity paste and electrical-isolation-film	$R_{TH\ case\text{-}heatsink}$ = ca. 1…1,5 °C/W

Therefore, If a heatsink is mounted on the converter, it's thermal resistance has to be at least:

$R_{THcase\text{-}ambient} = R_{THcase\text{-}heatsink} + R_{THheatsink\text{-}ambient} =$
$6.1°C/W - 1°C/W = 5.1°C/W$

If however, the results of your calculations or measurements are border-line, then the issue must be examined in more depth. So, for example, there is a difference in thermal performance between vertically and horizontally mounted modules, between static air and freely convecting air and with air at low atmospheric pressures.



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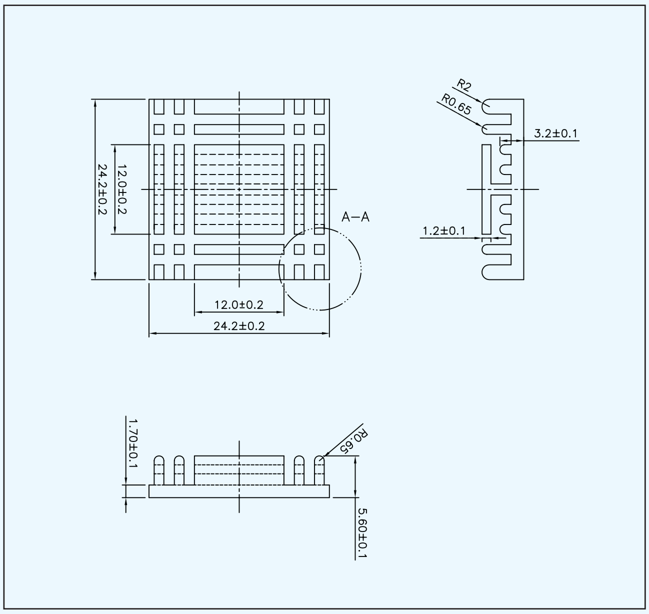
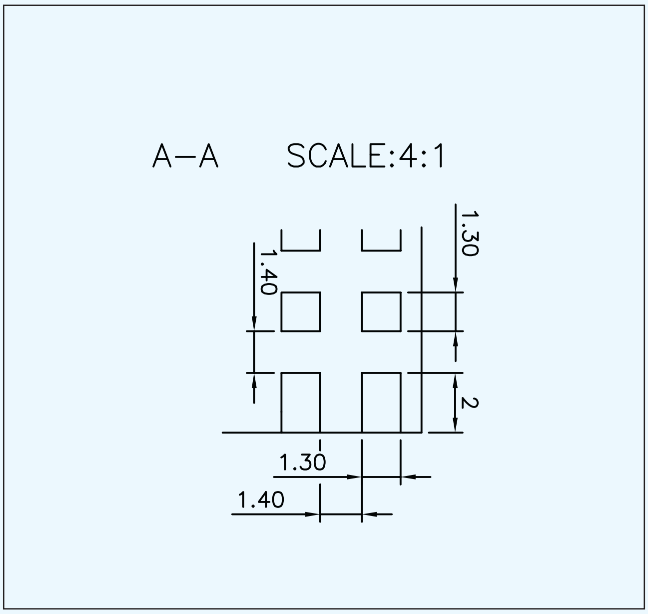
Heat Sinks available from Recom

7G-0047-F (12°C/W)





7G-0020C (9.5°C/W)